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A MODERN APPROACH FOR FERTIGATION UNDER GATED PIPES TECHNIQUE AND ITS IMPACT ON MAIZE PRODUCTIVITY AT NORTH NILE DELTA

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ABSTRACT

For improving nitrogen utilization efficiency by maize crop under gated pipes irrigation technique, a field experiment was conducted at El-Hamoul district, Kafr Elshiekh governorate during the summer season of 2011. The experiment included traditional furrow irrigation, gated pipes and alternative furrows irrigation by gated pipes technique, Two forms of mineral nitrogen fertilizers Urea ($CO(NH_2)_2$) and ammonium nitrate (NH_4NO_3) were applied at the recommended dose (135 Kg N Fed^{-1}) either as soil dressing or through irrigation as compared with the control treatment (without nitrogen application),

The main obtained results could be summarized as follows:

- Using gated pipes technique for irrigating maize crop resulted in less amount of water applied compared to traditional furrow irrigation method. On the other hand, gated pipes technique saved irrigation water by 19.74 and 30.77 % for gated pipe and alternative gated pipes techniques, respectively as compared with traditional furrow irrigation. This improved irrigation techniques led to decrease actual water consumptive use, improved water application efficiency and increased the contribution of ground water table in the crop water need.
- There was no effect on maize yield due to different irrigation techniques. However, gated pipes and alternative gated pipes recorded the highest values of grain yield (3.3 and 2.6 %) and stalk yield (47.6 and 15.1%) over the traditional furrow irrigation, respectively. Whereas, maize grain yield increased by about 62.1 , 59.7, 58.8 and 45.8 over control treatment due to application of ammonium nitrate applied by dressing method, urea applied with irrigation water, urea applied by dressing method and ammonium nitrate applied with irrigation water, respectively. Maize grain yield took the same trend of stalk yield. It can be observed that gated pipes technique for all furrows under ammonium nitrate applied by dressing method achieved the highest grain and stalk yields followed by treatment alternate furrows which irrigated by gated pipes under urea applied with irrigation water.
- The highest mean values of crop and field water use efficiencies were achieved under gated pipes alternative furrow techniques and Urea applied with irrigation water.
- Nitrogen use efficiency and N recovery % were increased with gated pipes irrigation techniques under ammonium nitrate applied by dressing method and urea applied with irrigation water
- Net income from water unit and economical efficiency increased with gated pipes techniques (for all furrow and alternative furrow) comparing with traditional furrow irrigation treatment.

Keywords: Furrow irrigation, Gated pipes irrigation technique, Nitrogen fertilization, Fertigation, maize crop.

INTRODUCTION

Increasing water productivity and nitrogen utilization efficiency are the main goal for increasing the water and fertilizer use efficiency. This can be achieved by managing the controlled modern surface irrigation systems and adjusting them to soil hydraulic properties and to the water and nutritional requirements of the specific crop growth.

Maize is one of the most strategically crop in Egypt to overcome the increasing requirement of maize grain for bread industry (20 %mixed with wheat flour, so reduce the imported quantity of wheat),animal and poultry feeding as well as many industrial purposes.

Great efforts have been made by Egyptian scientists to improve maize production by increasing the efficiency of adding fertilizer due to minimizing loss of nitrogen through leaching. This can be achieved by applying nitrogen fertilizer with irrigation gated pipes technique (fertigation).

Increasing the agricultural production per unit volume of water is the main goal through increasing the water use efficiency. This goal can be achieved by advanced surface irrigation through applying gated pipes for irrigating field crops. Gated pipe could save irrigation water by 16.94% for maize compared to traditional surface irrigation (Abo Soliman *et al.,* 2002).

On the other hand, the traditional surface irrigation system could be improved using gated pipes with the furrows or basin irrigation systems without major changes in the design or in the operating procedure of the current existed irrigation system. Gated pipes have low cost, relative high application and distribution efficiencies and it is easily to be used by the economic value experienced workers (Abou El-Soud, 2009).

Using gated pipes technique in irrigating alternative furrows under cultivation of maize and sugar beet crops combined with application of nitrogen recommended dose led to improve water and nitrogen use efficiencies, and save more irrigation water without significant reduction in maize and sugar beet yield specially, under limited of fresh water resources and high price of nitrogen fertilizers(Shabana, 2010).

It is well known that nitrogen is the most important element for plant growth and development, and it is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes (Mkhabela *et al.*., 2001).

Mkhabela *et al.*, (2001) examined in Swaziland the response of maize to different levels of nitrogen application, i.e. 0, 50, 100 and 150 Kg N ha-1. They found that grain yield and total dry matter were increased with increasing nitrogen application up to 100 Kg N ha-1.

The main objectives of this work are to find out the amount of water saving, maximum maize crop yield, water utilization and nitrogen use efficiency under different furrow irrigation systems.

MATERIALS AND METHODS

A field experiment was conducted during the summer season of 2011 at El Hamoul District, Kafr El Shiekh Governorate (4 m altitude, 31^{O} 25 31^{-} latitude and 31^{O} 04 23^{-} longitude) to study the nitrogen utilization efficiency under gated pipes irrigation technique with maize crop. To achieve this goal, the experimental field (2940 m^2) was divided into three plots to be occupied by the studied irrigation techniques (60*10 m^2 for each furrow irrigation treatments). Each experimental plot consisted of 24 rows. The gated pipes are located at the head of the field canal across the furrows and connected directly with the water pump. During maize crop, the area adjacent to maize was cultivated by rice.

The experimental design was Split Block design, the main plots were devoted to irrigation treatments which included three techniques (I), as follows:

- The traditional furrow irrigation technique (I_1)
- Gated pipes irrigation technique (I_2)
- alternative Gated pipe irrigation technique (I_3) (irrigating furrow and left the other furrow)., and

The sub plots were assigned to nitrogen application treatments, which were:

- N_1- control treatment (0 Kg N Fed^{-1})
- N_2- nitrogen was applied by dressing method in form of urea CO $(NH_2)_2$) at the recommended dose (135 Kg N Fed^{-1}).
- N_3- nitrogen was applied by dressing method in form (NH_4NO_3) ammonium nitrate (Recommended dose).
- N_4- Urea applied with irrigation water. (Recommended dose).
- N_5- Ammonium nitrate applied with irrigation water. (Recommended dose). The recommended dose is 135 Kg N Fed^{-1}.

Urea and ammonium nitrate fertilizer added with irrigation water through modified fertilizer unit connected to pump machine under furrow irrigation techniques. The fertilizer unit made from PVC tank (50 liter) connected to suction pipes through steel valve. The fertilizers dissolved in water then transported through delivery pipes. The cost of this fertigation process heads which included the PVC tank and valve is low and not expensive.

Maize grains, cultivar triple cross (Sakha 324) were sown on June 15^{th}, 2011. Nitrogenous fertilizers in the form of urea and ammonium nitrate were divided into three equal doses, the first dose was applied before the second irrigation, the second dose was applied before (the third irrigation) and the third dose was applied before the fourth irrigation. Potassium fertilizer (recommended dose) was applied as potassium sulphate (48 % K_2O), and Phoshorus (recommended dose) in the from of Ca-superphosphate (15.5%P_2O_5) were added with soil preparation.

Soil analysis

- Soil samples were collected from different layers and subjected to the following hydrophysico- chemical analysis according to Richards (1954) and Jackson (1967).

- Moisture parameters; Field capacity (F.C.) and permanent wilting point (P.W.P) were determined by pressure membrane method according to Klute (1986).
- Some chemical and physical properties of the experimental soil are shown in Tables (1-2).

Table (1): Some chemical properties of the experimental soil before the growing season

Soil depth (cm)	Particle size distribution			Texture	Basic infiltration rate (cm/hr)	Bulk density (g/cm^3)	Soil moisture characteristics		
	Sand %	Silt %	Clay %				Field capacity %	Wilting point %	Available water %
0-15	16.89	23.97	59.14	clayey	1.4	1.16	41.1	22.3	18.8
15-30	16.55	25.57	57.88	clayey		1.24	40.1	21.8	18.3
30-45	16.22	24.52	59.26	clayey		1.33	38.6	20.8	17.8
45-60	17.60	26.26	56.14	clayey		1.37	38.2	20.7	17.5

*** pH was determined in soil water suspension (1:2.5).**
**** EC was determined in saturated soil paste extract.**

Table (2). Some physical properties of the experimental soil before the growing season.

Soil depth (cm)	OM %	pH*	EC** (dS/m)	Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})				SAR	Available nutrients (ppm)		
				Na^+	K^+	Ca^{++}	Mg^{++}	CO^-	HCO^{-3}	Cl^-	$SO4^{--}$		N	P	K
0-15	1.21	8.25	2.43	16.5	0.2	3.9	5.3	0	5.2	11.6	9	7.69	59.3	9.4	331
15-30	1.20	8.22	2.85	19.4	0.3	4.6	6.3	0	7.1	13.6	9.7	8.33	63.8	9.9	333
30-45	0.91	8.26	3.5	23.8	0.4	5.6	7.7	0	7.8	16.7	12.1	9.23	42.6	9.6	323
45-60	0.56	8.29	6.17	42.0	0.6	9.9	13.6	0	7.5	29.4	29.1	12.25	31.9	9.5	317

- **Amount of water applied:-**
  Traditional surface irrigation: the applied irrigation water was measured by using cut –throat flume (20 x 90 cm) according to Early (1975).
  Improved surface irrigation (gated pipes): the discharge through an orifice was determined as described by (Brater and King 1976). Applied water (AW): was calculated as described by Giriappa (1983) as follows: AW=IW+ER+S, where IW= irrigation water applied, ER=effective rain and S= amount of soil moisture contribution to consumptive use from the shallow ground water table.
- **Contribution of ground water table** as a percentage of the consumptive use was calculated as follows:
  GWC%= (ETc- SMD)/ETc x 100, where ETc= Crop evapotarnspiration = ETxKc and SMD= soil moisture depletion. (Cited from Khalifa, 2013)
- **Water consumptive use (CU)**: was calculated using the equation of Israelson and Hansen (1962).
- **Irrigation application efficiency (Ea):** Values of irrigation application efficiency (Ea) in percent for each treatment were obtained according to Downy (1970) as follows:

$$Ea = \frac{Ws}{Wd} \times 100$$ where:

Ea = Water application efficiency (%)
Ws= Water stored in the effective root zone
Wd = Water applied to the field plot.

- **Maize yield:** data of the grain yield was adjusted based on the moisture percent of 15.5 %
- **Crop water use efficiency (CWUE).**
  It was calculated by the following equation according to Abd El -Rasool *et al.*, (1971).

$$C.W.U.E. = \frac{\text{Yield (Kg fed}^{-1})}{\text{Water consumptive use (m}^3\text{ fed}^{-1})}$$

- **Field water use efficiency (FWUE).**
  It was calculated in Kg m^{-3} for different irrigation systems to clarify how much Kg yield is produced from one cubic meter applied (Michael,1978)
- **Nitrogen in plant:** was determined in grain and stalk digestion by micro-Kjeldahl method as explained by Hesse (1971). The uptake of nutrients by plant organs (grain and stalk) was calculated by multiplying element concentration by dry weight of plant for maize.
- **Nitrogen use efficiency** was calculated as grain yield (Kg) produced due to adding unit of nitrogenous fertilizer.
- **Nitrogen recovery %**
  Apparent nitrogen recovery of fertilizer (%) was calculated for each treatment according to the following equation (Crasswell and Godwin , 1984)

$$\textbf{Recovery of N fertilizer \%} = \frac{\textbf{-uptake from fertilized plot – N-uptake from control}}{\textbf{N-applied from fertilizer}} \textbf{ X 100}$$

Statistical analysis

Data were statistically analyzed using analysis of variance (ANOVA). Treatments means and significance of differences were calculated and presented using (LSD) according to Duncan (1955). All statistical analyses were performed using analysis of variance technique by mean of CoHort Computer software

RESULTS AND DISCUSSION

Some water relations:-

Amount of irrigation water applied.

Data in Table (3) show that using gated pipes techniques resulted in less amount of water applied compared to traditional furrow method. The lowest amounts of water applied were achieved by I_3 (alternative gated pipes technique), followed by I_2 (gated pipes technique), where the highest one was obtained from traditional method I_1. It is worthy to mention that, gated pipes

technique saved irrigation water by 19.74 and 30.77 % for I_2 and I_3, respectively. These results are in a good agreement with those obtained by Abo Soliman, *et al.* (2002) and Abou El-Soud (2009).

Contribution of ground water to ETc (cm):-

Values of contribution of ground water to maize crop are presented in Table (3). Data reveal that by increasing the water applied, less values of contribution of ground water table (cm) was obtained. So, less contribution (S) was obtained under using traditional surface furrow irrigation (I_1) which was found 13.97 cm (as an average). These results are in harmony to those recorded by khalifa (2013)

On the other hand, the highest ground water contribution was obtained under I_3 techniques (14.39 cm). So, contribution of GW was increased directly by increasing the water applied from the area adjacent to maize is cultivated by rice, this resulted in water movement causing upward flow and contribution the water table in irrigation. The less contribution of water table might be attributed to the less water consumed by plants at both early and maturity stages. Results of ground water contribution could be differed according to the growth, irrigation treatments and water table depth (Kahlown *et al.*, 2005).

Water stored:-

Water stored in the effective root zone (Table 3) is one of the most important criteria which related to the field irrigation efficiency with different furrow irrigation techniques. Meanwhile, the highest amount of water stored under maize crop is 2369.64 m^3 fed^{-1} under traditional surface furrow irrigation, while the lowest of amount water stored was obtained under alternate furrow irrigated by gated pipes (I_3) technique (1805.58 m^3 fed^{-1}).

Actual water consumptive use:-

Data in Table (3) indicate that the seasonal water consumptive use values by maize crop were affected by furrow irrigation methods .The highest value (2359.79 m^3 fed^{-1}) was obtained from traditional furrow irrigation technique (I_1), while, the lowest one was obtained under (I_3) alternative gated pipes technique (1768.47 m^3 fed^{-1}) followed by gated pipes technique (I_2). These results are in somewhat similar to those recorded by Abo Soliman *et al.,* (2002) and Abou El-Soud (2009).

Water application efficiency:-

Data in Table (3) reveal that the highest value of water application efficiency (74.66 %) was achieved under gated pipes (I_2), while the lowest one (66.15 %) was detected under (I_1) treatment. It was expected that application efficiency was improved by 8.5 % and 6.7 % due to irrigation with gated pipe (I_2) and alternative gated pipe (I_3), respectively compared to traditional irrigation (I_1). This may be due to the uniform water distribution from the outlet of gated pipe compared to traditional surface irrigation which tend to reduce the percolation losses. These results agreed with numerous investigators like Abo Soliman *et al.,* (2002) and Abou El-Soud (2009).

Table (3): Water consumptive use, water stored, water applied (IW and S), water saving % and irrigation water applied efficiency % as affected by different treatments during maize growing season.

Surface irrigation methods*	Water consumptive use (m^3 fed^{-1})	Water stored (m^3 fed^{-1})	Irrigation water applied (IW)	Amount of contribution (S)	Applied water (AW)	Irrigation application efficiency %	water saving %
			(m^3 fed^{-1})				
I_1	2359.79	2369.64	3003.00	579.18	3582.18	66.15	0
I_2	2048.21	2146.62	2320.92	553.98	2874.90	74.66	19.74
I_3	1768.47	1805.58	1875.30	604.38	2480.10	72.81	30.77

*** I1: irrigation all furrows by traditional surface I2: irrigation all furrows by gated pipes**
I3: Alternate furrow irrigation by Gated pipes

Yield:

Irrigation effect:

Data in Table (4) reveal that an insignificant effect on grain and stalk yield of maize was obtained due to irrigation treatments. Modern irrigation techniques (I_2 and I_3) treatments led to increase grain yield (3.3 and 2.6 %) and stalk yield by (47.6 and 15.1%)as compared to traditional surface irrigation (I_1), respectively.

Nitrogen fertilization effect

As shown in Table (4) high significant effect due to forms and method of application nitrogen fertilizer was resulted on grain and stalks yield. the highest grain yield was achieved by using (N_3) Ammonium nitrate applied by dressing method, which produced the highest mean values of maize grain yield (4285.3 Kg Fed^{-1}) followed by (N_4) Urea applied with irrigation water(4199.8 Kg Fed^{-1}).

Maize grain yield increased by about 62.1 %, 59.7%, 58.8% and 45.8% over control treatment (0 Kg N Fed -1) due to application of N_3, N_4, N_2 and N_5, respectively. The grain yield is reflection of stalk yield, so it is logically that maize grain yield took the same trend of stalk yield.

It is well known that nitrogen is the most important element for plant growth and development, and it is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes (Mkhabela *et al.*., 2001).

Table (4): Effect of irrigation and nitrogen fertilization on grain and stalk yield (Kg fed^{-1}) of maize crop.

Treatments	Grain yield (Kg fed^{-1})	Relative change %	Stalk yield (Kg fed^{-1})	Relative change %
Irrigation Treatment				
I_1	3607.13a	0.0	13069.33c	0.0
I_2	3727.03a	+3.3	14785.33a	+47.6
I_3	3701.91a	+2.6	13613.33b	+15.1
F-Test	ns	-	***	-
LSD at 0.05	120.10	-	193.89	-
Nitrogen fertilization				
N_1	2044.87c	**0.0**	10116.66e	**0.0**
N_2	4167.52a	**+58.8**	14483.33c	**+121.1**
N_3	4285.32a	**+62.1**	15670a	**+154.0**
N_4	4199.77a	**+59.7**	15101.11b	**+138.2**
N_5	3695.96b	**+45.8**	13742.22d	**+100.5**
F-Test	***	-	***	-
LSD at 0.05	137.15	-	406.7	-

Interaction effect:

The influence of interaction between irrigation treatments and nitrogen fertilization on maize yield was significant for grain and stalk yield. It can be observed from Table (5) that gated pipes technique for all furrows (I_2) under N_3 achieved the highest grain and stalk yields followed by treatment (I_3) alternate gated furrows under N_4 than traditional furrow irrigation treatment (I_1) under N_3, this is related to the improvement of soil aeration conditions, more uniformity of water distribution along the furrow, (Morsi, 2001), enhancing root system (primary root number, root density and total root dry weight), (Kang *et al.*., 2000) and enhancing water and nutrients uptake (Abdel-Maksoud *et al.*., 2002).

Table (5): The interactions effect between irrigation system and nitrogen fertilization treatments on maize grain and stalk yields (Kg Fed $^{-1}$).

Treatments		Grain	Stalk
I_1	N_1	1746.1f	5616.66f
	N_2	4287.4 abc	14580 b
	N_3	4292.73abc	16773.33a
	N_4	4026.36c	14343.33b
	N_5	3683.06d	14033.33bc
I_2	N_1	2207.3 e	12356.66e
	N_2	4078.73c	14370 b
	N_3	4496.76a	16663.33a
	N_4	4173.4 bc	16356.66a
	N_5	3678.96d	14180 bc
I_3	N_1	2181.23e	12376.66e
	N_2	4136.43bc	14500 b
	N_3	4066.46c	13573.33cd
	N_4	4399.56ab	14603.33b
	N_5	3725.86d	13013.33d
F Test		**	***
LSD at 0.05		276.16	597.3

Water use efficiency of maize:

Data in Fig (1) show a highly significant effect of irrigation technique on crop and field water use efficiencies (CWUE and FWUE). The highest mean value (2.3 and 1.7 kg grain / m^3) was achieved under alternative gated pipes techniques (I_3) and (N_4) Urea applied through irrigation water. Whereas, the lowest mean value was detected under most of irrigation technique and zero nitrogen.

It could be observed from the data that the use of the modern gated pipes techniques I_2 and I_3 are better than the traditional surface furrow irrigation technique. The differences in FWUE and CWUE values with different furrow irrigation techniques are attributed to the amounts of the water applied and consumed as well as the crop productivity.

By other words, using modern irrigation by gated pipes improved FWUE and CWUE values. This may be attributed to the amounts of the water applied and consumed as well as the crop productivity. These results are in harmony with those recorded by Abo Soliman ,*et al.* (2002), Sonbol,*et al.* (2009) and Abou El-Soud (2009).

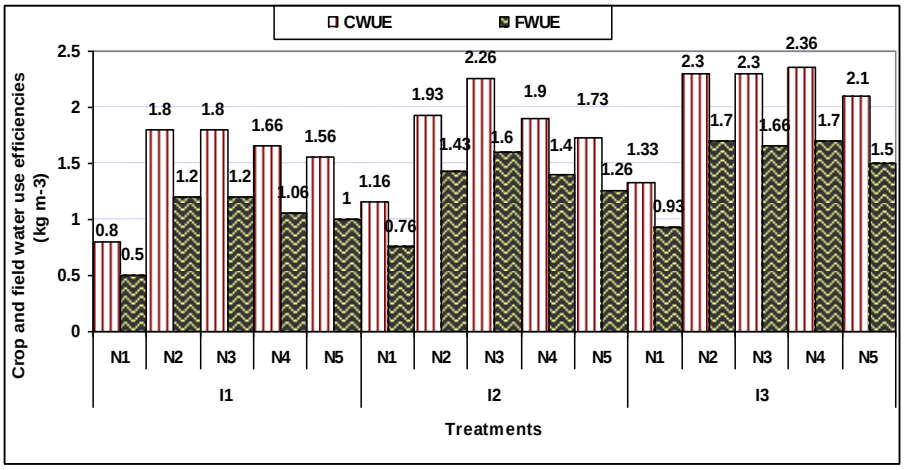

Fig (1): Crop (CWUE) and field (FWUE) water use efficiencies as affected by irrigation system and nitrogen fertilizer application methods with maize grain yield.

Nitrogen concentration and uptake by maize crop:

Irrigation effect:

Data in Table (6) illustrate the impact of irrigation treatments on nitrogen concentration and its uptake by maize. It can be observed that nitrogen concentration increased under gated pipes irrigation techniques (I_2 and I_3) compared to traditional irrigation treatment (I_1).

This result may be resulted from the improving of furrow irrigation which enhanced root volume as a result of good aeration and improving soil physical properties (Kang *et al.*., 2000) & (Morsi 2001), then improving root volume which increased nitrogen uptake. Similar results were also obtained by Aiad 2003 and Mosa 2006.

The highest mean values of nitrogen concentration in maize grains and stalks are detected with I_2 followed by I_3.

Nitrogen uptake takes the same trend of nitrogen concentration, as nitrogen uptake is high significantly increased with decreasing irrigated furrows.

There is no doubt that nutrient concentration in stalk tissues reflects its concentration on grains, so it can notice from Table 6 that there is good relation between the nitrogen concentration in stalk and grains of corn.

Nitrogen fertilization effect:

Data illustrated in Table (6) show that nitrogen concentration (%) and uptake (Kg Fed^{-1}) of both grain and stalk organs increased with (N_4) urea applied with irrigation water and (N_3) ammonium nitrate applied by dressing method.

The highest amounts of nitrogen uptake by grains and stalks were 44.74 and 48.58 Kg N Fed-1 respectively were found under (N_4) and (N_3). whereas , the lowest ones were detected under control treatment (15.69 and 18.64 Kg N Fed-1) for grain and stalk, respectively.

Table (6). Effect of irrigation systems and nitrogen fertilization treatments on nitrogen concentration and uptake by maize crop .

Treatments	Nitrogen concentration (%)		Nitrogen uptake (kg fed^{-1})	
	Grain	Stalk	Grain	Stalk
Irrigation Treatment				
I_1	1.07b	1.29 c	33.55 b	30.01c
I_2	1.21a	1.92a	38.61a	48.95a
I_3	1.14ab	1.67b	36.31ab	38.73b
F-Test	*	***	*	***
LSD at 0.05	0.07	0.059	3.45	1.58
Nitrogen fertilization				
N_1	0.90d	1.04d	15.69d	18.61c
N_2	1.13c	1.61c	39.73b	39.36b
N_3	1.21ab	1.83ab	43.57a	48.58a
N_4	1.26a	1.87a	44.74a	48.34a
N_5	1.19bc	1.78b	37.06c	41.26b
F-Test	***	***	***	***
LSD at 0.05	0.06	0.087	1.38	2.59

Interactions effect:

Data in Table (7) reveal the interaction effect between irrigation techniques and nitrogen fertilization on nitrogen concentration and uptake by grain and stalk.

Concerning nitrogen concentration and uptake, it is obvious that the interactions between irrigation and nitrogen fertilization effect were highly significant on stalk and insignificant on grains.

Regarding data of nitrogen concentration in grains and stalks, It can be observed that gated pipes irrigation techniques (I_2) under (N_4) urea applied with irrigation water was the superior irrigation treatment, and this may attributed to less nitrate leaching, and so increasing nitrogen concentration in

soil, resulting increasing in nitrogen uptake. Similar results were obtained by Abde-Maksoud *et al.*., (2002) and Mosa, (2006).

Table (7). Interaction effect between irrigation and nitrogen fertilization treatments on nitrogen concentration (%) and nitrogen uptake (kg fed^{-1}) of grains and stalks

Treatments		Nitrogen concentration (%)		Nitrogen uptake (kg fed^{-1})	
		Grain	Stalk	Grain	Stalk
I_1	N_1	0.80f	0.84f	11.83e	8g
	N_2	1.07de	1.34d	38.7b	33.17e
	N_3	1.18bcd	1.46d	42.53ab	41.5cd
	N_4	1.26ab	1.41d	42.67ab	34.2e
	N_5	1.03e	1.39d	32c	33.2e
I_2	N_1	1.02e	1.14e	18.97d	23.77f
	N_2	1.22abc	2.02b	41.8ab	49.03b
	N_3	1.22abc	2.24a	46.07a	63.1a
	N_4	1.32a	2.25a	46.5 a	62.33a
	N_5	1.28ab	1.94bc	39.73b	46.5bc
I_3	N_1	0.88f	1.14e	16.27 d	24.07f
	N_2	1.11cde	1.46d	38.7b	35.87e
	N_3	1.23abc	1.79c	42.1ab	41.16d
	N_4	1.22abc	1.97 bc	45.07a	48.5b
	N_5	1.26ab	2.01 b	39.43b	44.07bcd
F Test		ns	***	ns	***
LSD at 0.05		0.12	0.182	4.43	4.86

Nitrogen use efficiency (NUE)

It is defined as the amount of harvested crop which produced from the unit of nitrogen supplied during the growing season. The effects of irrigation technique on nitrogen use efficiency are shown in Fig (2). Data clearly show that the highest values of nitrogen use efficiency were obtained by gated pipes irrigation techniques (I_2) under (N_3) Ammonium nitrate (NH_4NO_3) applied by dressing method, followed by gated pipes alternative furrow irrigation techniques (I_3) under (N_4) Urea applied with irrigation water and followed by traditional furrow irrigation technique (I_1) under (N_3) Ammonium nitrate applied by dressing method. This may be due to uniform water distribution from the outlet of gated pipes compared to traditional furrow irrigation which tends to reduce the percolation losses and less nitrate leaching, and so increasing nitrogen concentration in root zone, resulting in increasing the nitrogen uptake and increasing grain yield. Similar results were obtained by Abdel-Maksoud *et al.*., (2002) and Mosa, (2006).

Nitrogen -recovery:

Fig (2) shows the total nitrogen recovery by the whole maize plant (grains & stalks) at maturity stage. The highest value of N recovery % was found under (I_2) with (N_3) and (N_4), followed by (I1) under (N_3) and followed by (I3) under (N_4). Similar results were obtained by Shabana (2010).

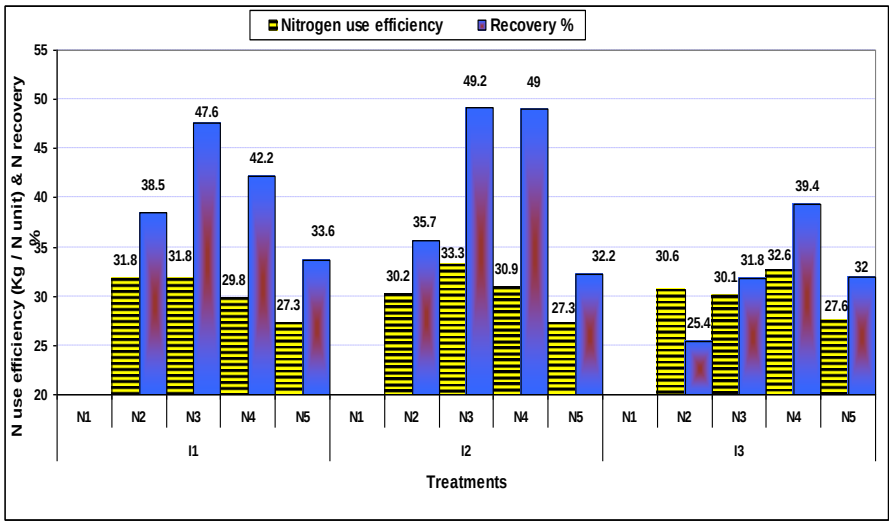

Fig (2). Effect of irrigation treatments on nitrogen use efficiency and N recovery for maize crop.

Economical evaluation:

Data tabulated in table (8) show that, the highest total income (8430.3 L.E/fed) net income (6085.3 L.E/fed) ,net income from water unit (2.34 L.E/m^3) and economical efficiency (2.60) were obtained with gated pipes alternative furrow irrigation techniques (I_3) under (N_4) urea applied with irrigation water, followed by (I_3) under (N_3) for total income (8677.4L.E/fed) net income (5893.6 L.E/fed) ,net income from water unit (2.07 L.E/m^3) and economical efficiency (2.45) with (N_4) and (2.12) with (N_3) ,while the lowest values of net income from water unit (0.42 L.E/m^3) and economical efficiency (0.76) were recorded with traditional furrow irrigation technique (I_1) under zero application of nitrogen.

In addition to net income from water unit and economical efficiency increased with Gated pipes (I_2 and I_3) comparing with traditional furrow irrigation treatment (I_1). This may be due to the uniform water distribution from the outlet gated pipes compared to traditional furrow irrigation which tends to reduce the percolation losses and less nitrate leaching, and so increasing nitrogen concentration in root zone and increasing grain yield. These results are an agreement with those recorded by khalifa (2013).

Table (8) Net income, Net income from water unit and economical efficiency of maize crop as affected by irrigation and nitrogen fertilization treatments.

Treatments		Grain yield	Stalk yield	Income (L.E/fed)		T. income	T. cost	Net income	A.W	Net income from water unit	Economical efficiency
		(Kg fed^{-1})	(Kg fed^{-1})	Grain	Stalk	(L.E/fed)	L.E/fed	L.E/fed	m3/fed	L.E/m3	
I_1	N_1	1746.1	5616.7	3143.0	196.6	3339.6	1895	1444.6	3417.1	0.42	0.76
	N_2	4287.4	14580.0	7717.3	510.3	8227.6	2615	5612.6	3574.1	1.57	2.15
	N_3	4292.7	16773.3	7726.9	587.1	8314.0	2783.75	5530.2	3541.3	1.56	1.99
	N_4	4026.4	14343.3	7247.4	502.0	7749.5	2345	5404.5	3758.7	1.44	2.30
	N_5	3683.1	14033.3	6629.5	491.2	7120.7	2513.75	4606.9	3619.5	1.27	1.83
Mean		3607.1	13069.3	6492.8	457.4	6950.3	2430.5	4519.8	3582.2	1.3	1.81
I_2	N_1	2207.3	12356.7	3973.1	432.5	4405.6	1895	2510.6	2742.6	0.92	1.32
	N_2	4078.7	14370.0	7341.7	503.0	7844.7	2615	5229.7	2868.6	1.82	2.00
	N_3	4496.8	16663.3	8094.2	583.2	8677.4	2783.75	5893.6	2842.3	2.07	2.12
	N_4	4173.4	16356.7	7512.1	572.5	8084.6	2345	5739.6	3016.8	1.90	2.45
	N_5	3679.0	14180.0	6622.1	496.3	7118.4	2513.75	4604.7	2905.1	1.59	1.83
Mean		3727.0	14785.3	6708.7	517.5	7226.1	2430.5	4795.6	2875.1	1.7	1.94
I_3	N_1	2181.2	12376.7	3926.2	433.2	4359.4	1895	2464.4	2365.7	1.04	1.30
	N_2	4136.4	14500.0	7445.6	507.5	7953.1	2615	5338.1	2474.3	2.16	2.04
	N_3	4066.5	13573.3	7319.6	475.1	7794.7	2783.75	5010.9	2451.6	2.04	1.80
	N_4	4399.6	14603.3	7919.2	511.1	8430.3	2345	6085.3	2602.2	2.34	2.60
	N_5	3725.9	13013.3	6706.5	455.5	7162.0	2513.75	4648.3	2505.8	1.86	1.85
Mean		3701.9	13613.3	6663.4	476.5	7139.9	2430.5	4709.4	2479.9	1.9	1.92

Economical efficiency= net income /total cost Net Income from water unit (L.E/m) = net income /AW

Conclusion

►Using gated pipes technique for irrigating maize crop in combination with application of urea applied with irrigation water led to improve water application efficiency, contribution of ground water table, nitrogen efficiencies, saving more water, net income, net income from water unit and economical efficiency without observed reduction in maize crop yield.

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نظام جديد للتسميد مع الري تحت تقنية الري بالمواسير المبوبه وأثر ذلك علي معدل انتاجية محصول الذرة في شمال الدلتا

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لتحسين كفاءة استخدام الاسمده تحت تقنية الري بالمواسير المبوبه على بعض العلاقات المائية وكفاءات استخدام النتروجين و انتاجية محصول الذره اقيمت تجربة حقلية في مركز الحامول بمحافظة كفرالشيخ في شمال الدلتا.

و أهم النتائج المتحصل عليها:-

- استخدام المواسير المبوبه في ري محصول الذره نتج عنه تقليل كمية الماء المضافة مقارنة بالري السطحي التقليدي ، ومن ناحية أخرى تم توفير كمية مياه ري بمقدار ١٩.٧٤ و٣٠.٧٧% لتقنيةِ المواسير المبوبه والري التبادلي بالمواسير المبوبة على الترتيب مقارنة بالري السطحي التقليدي, كما حقق الري بالمواسير المبوبه أقل قيم للإستهلاك المائي الفعلي وحسن من كفائة تطبيق الماء ومساهمة الماء الارضي وكفائة اسخدام النتروجين مقارنة بالري السطحي التقليدي وكفاءات استخدام المياه (المحصولي – الحقلي) تحت الكمية الموصى بها من التسميد النيتروجيني بنترات الامونيوم تكبيش ثم اليوريا مع الري. ولا يوجد تأثير معنوي على محصول الذرة عند استخدام نظم الري المختلفة تحت هذة الدراسة بينما زاد محصول الحبوب بحوالي (٣.٣ و٢.٦ %) ومحصول القش بحوالي (٤٧.٦ و١٥.١ %) بالمقارنة مع الرَيِّ السطحي التقليدي، على التوالي. بينما، محصول الحبوبِ زادَ بمقدار حوالي ٦٢.١%، ٥٩.٧ %, ٥٨.٨% و٤٥.٨ % عن معاملة الكنترول (بدون تسميد) بسبب تطبيقِ نتراتِ الأمونيومِ تكبيش، اليوريا في ماءِ الرَيِّ، اليوريا تكبيش ونتراتِ أمونيومِ في ماءِ الرَيِّ، على التوالي. إنّ محصولَ الحبوبَ إنعكاسُ محصولِ القش. ومن التفاعل بين طرق الريَ والتسميد النيتروجيني حقق تقنيةِ الري بالمواسير المبوبه كُلّ الخطوط تحت نترات الأمونيوم تكبيش حقق الأعلى في محصول الحبوبَ تبعه تقنية الري التبادلي بالمواسير المبوبة تحت اليوريا في ماءِ الرَيِّ.
- صافي الدخل والكفائة الاقتصادية زاد باستخدام المواسير المبوبه (كل الخوط او التبادلي) مقارنة بالري السطحي التقليدي, وكان الزيادة مع الكمية الموصى بها من التسميد النيتروجيني باليوريا مع الري.

قام بتحكيم البحث

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